^{241}Am-^{9}Be Source for Neutron and γ-Ray Calibrations of SNO

E. B. Norman, A. R. Smith, J. Trigg, and Y. D. Chan & the LBNL/SNO Group

^{241}Am-^{9}Be sources are used in laboratories all over the world as neutron calibration sources. They produce neutrons via the ^{9}Be(α,n) ^{12}C reaction, which has a Q-value of + 5.701 MeV. This reaction almost always leads to either the ground state or the first excited state of 12C. In the latter case, a 4.44 MeV γ ray is then emitted. In a careful study of a number of different ^{241}Am-^{9}Be sources, Croft [Ref 1] found that the ratio of 4.44 MeV γ rays to neutrons emitted by such sources is 0.6, essentially independent of the details of the manner in which the source was prepared. Thus sixty percent of the neutrons emitted by such sources are in prompt coincidence with 4.44-MeV γ rays. We have made use of this characteristic to manufacture a ^{241}Am-^{9}Be source that can be used to determine the neutron lifetime and neutron detection efficiency in SNO. This device will also provide a new point that will aid in determining SNO's energy calibration at low energy.

We purchased a 10-microCurie ^{241}Am γ source from Isotope Products Laboratories. For a target, we purchased a 0.005-cm thick 99.5% pure beryllium foil from Alfa/Aesar Co. This foil is thick enough to stop all of the alphas emitted by the ^{241}Am source. For a holder, we built a double capsule Teflon enclosure using a design from Queen's University. Teflon was chosen as a capsule material because of its low neutron-capture cross sections, its inert chemical property, and its low radioactivity. The source was assembled and tested in a variety of ways at LBNL. The fully assembled double capsule was tested under 110 psig. pressurized water for a period of 5 days. No leaks were found. The source was counted for both neutrons and γ rays in LBNL's Low Background Counting Facility and in a separate counting lab at the 88" Cyclotron. The measured neutron and γ -ray emission rates were found to be consistent with the calculated values of seven neutrons per second and four 4.44-MeV γ rays per second.

This source requires no electrical connections or gas lines. When deployed in SNO, the 4.44 MeV γ -ray will produce a prompt Cerenkov event that usually will be followed, some milliseconds later, by a second Cerenkov event caused by the capture of the neutron on ^{35}Cl. In analyzing the data, one needs to search for two types of events: (1) isolated 4.44 MeV events, and (2) pairs of events in which a 4.44 MeV γ ray is followed within a time window of say 50 milliseconds by an 8.6 MeV event. To obtain the neutron lifetime in SNO, one simply plots the number of such event pairs observed as a function of the time between 4.44- and 8.6-MeV events. One will observe an exponential decay curve from which the lifetime can be extracted. Every 4.44-MeV γ ray is emitted with exactly one neutron in coincidence with it. Thus, to obtain SNO's neutron detection efficiency, one simply divides the number of 4.44-MeV, 8.6-MeV coincident events by the total number of 4.44-MeV events. This source thus allows us to determine SNO's neutron detection efficiency without having to know the source strength. In order to aid in the energy calibration at low energies, one can also obtain an essentially background free 4.44 MeV γ -ray peak by looking for an 8.6 MeV event and then looking backward in time by say 25 milliseconds for the preceding 4.44 MeV event.

Monte Carlo simulations of what one will actually observe in SNO from this source are now in progress. The source assembly has been shipped to Queen's University where it will undergo a radon emanation test and a leaching test. After this test is completed, the source will be ready for deployment in SNO.

References

1. S. Croft, Nucl. Instr. Meth. A281 (1989) 103.